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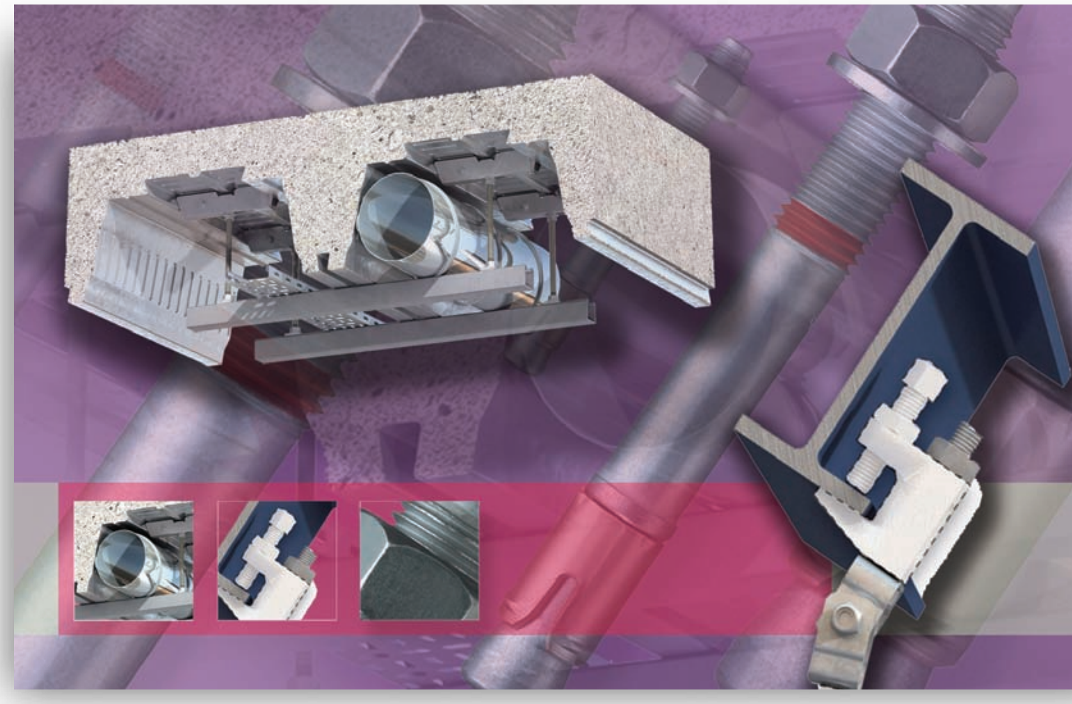
Structural Fixings for Ductwork Systems



By Glenn Hawkins

A joint venture with

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ACKNOWLEDGEMENTS

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FOREWORD

Malcolm Moss, President, ADCAS

The built environment is composed of buildings and other structures that contain a complex network of pipework, ductwork, lighting, power and control systems. These building services need to be positioned in a way that will enable them to fulfil their functional requirements. They also need to be supported in a manner that safely transfers their load to the building structure without causing damage to the structure or to the elements being supported.

This document provides guidance about the design, selection and installation of structural fixings for ductwork systems. It does not aim to cover every ductwork system application, every type of structural fixing, or every type of structural base material. Instead, it provides an overview of the design process that should be applied to the design of ductwork support systems, examines how fixings function and how they fail, and then complements this information with guidance about the selection and installation of structural fixings for solid concrete, hollowcore concrete slabs, composite decking, steelwork, masonry, and timber.

At ADCAS we are constantly promoting the need to maintain the highest possible standards, not just in the ductwork sector, but across the whole construction industry. It's a policy that depends on accurate, easy to understand sources of information on how to do things the right way. We are delighted to bring this new guide to best practice to the market – a guide that's backed by the wealth of experience within BSRIA.

The availability of clear and precise information on the best methods and product options is vital to clients throughout the supply chain, ensuring they can rely on effective and safe installation methods for all their projects.

We are confident that this guide will be valued as a must-have document by designers and installers alike for many years to come.

Malcolm Moss, July 2010

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Ductwork support systems are composed from three principal elements:

- An element that fixes to the structure of a building, such as an anchor or a clamp
- A hanger arrangement, the length of which can be adjusted to position the ductwork system component correctly within the building
- An element that connects to, or wraps around, the ductwork system component to retain it in position.

Figures 1 – 6 provide examples of ductwork support configurations.

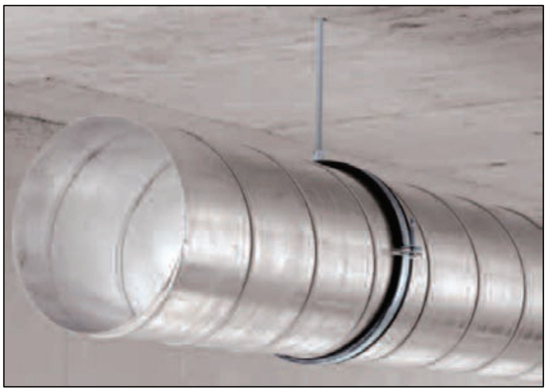


Figure 1: Circular ductwork suspended from a solid concrete slab. A knock-in expansion anchor, threaded drop-rod and noise-insulated duct ring have been used.

Figure 2: A ductwork riser supported from concrete riser shaft walls. Stud expansion anchors, a profiled channel system and duct angle-brackets have been used in this support configuration.

Figure 3: Rectangular ductwork suspended from a steel beam. Beam clamps, threaded rod and a profiled channel system have been used for this support configuration.

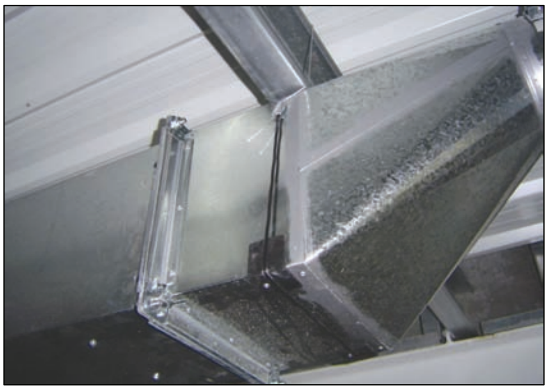


Figure 4: Rectangular ductwork suspended from a steel purlin. Wire rope and corner saddles have been used for this type of support.

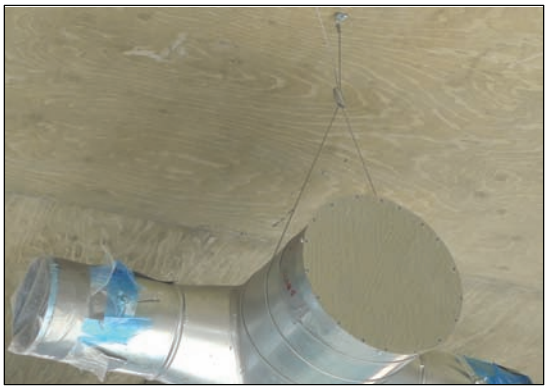


Figure 5: Circular ductwork suspended from a solid concrete slab using wire rope with a 90° end fixing. A nail anchor has been used to make the connection to the structure.

Figure 6: A prefabricated services module containing pipework, ductwork and electrical systems. This module will be elevated into position and fixed to the structure as a single element.

Ductwork support systems are not covered by any specific legislation. However, the safety of buildings during construction, occupancy and use is covered in the following legislation:

- *The Health and Safety at Work Act 1974* and subsidiary regulations
- *The Construction (Design and Management) (CDM) Regulations* 2007
- *The Construction Products Directive*
- *The Building Regulations 2000* – specifically the *Approved Documents*.

The *Health and Safety at Work Act 1974* places a general duty on employers to consider the safety of employees and others who may be affected by work activities. It is applicable to the construction phase, subsequent maintenance and operation activities and the safety of future occupants of the building.

The *CDM Regulations* place a duty on construction project teams to plan a safe method of construction and undertake a risk assessment of the proposed construction works and the safety of the design.

The *Construction Products Directive* calls for the testing and certification of products used in the construction industry, including provisions for CE marking. The *Directive* contains essential requirements for the performance of works in relation to the following six criteria:

- Mechanical resistance and stability
- Safety in the case of fire
- Hygiene, health and the environment
- Safety in use
- Protection against noise
- Energy economy and heat retention.

In order to demonstrate compliance with the *Construction Products Directive*, products can be tested and certified against specific standards.

Regulation 7 of *The Building Regulations* states that:

Building work shall be carried out:

(a) with adequate and proper materials which:

(i) are appropriate for the circumstances in which they are used

(ii) are adequately mixed or prepared; and

(iii) are applied, used or fixed so as adequately to perform the functions for which they are designed; and

(b) *in a workmanlike manner*

Building Regulations Approved Document 7 – Materials and Workmanship describes ways of establishing the fitness of materials and the adequacy of workmanship.

A great variety of construction materials, structural designs, ductwork system layouts and support system components are employed in the built environment. This means that there is an extensive range of ductwork support options available to construction project teams.

In order to arrive at an effective and economical solution for a particular ductwork system installation, construction project teams should adopt the seven stage process for the design of ductwork support systems as shown in Figure 7.

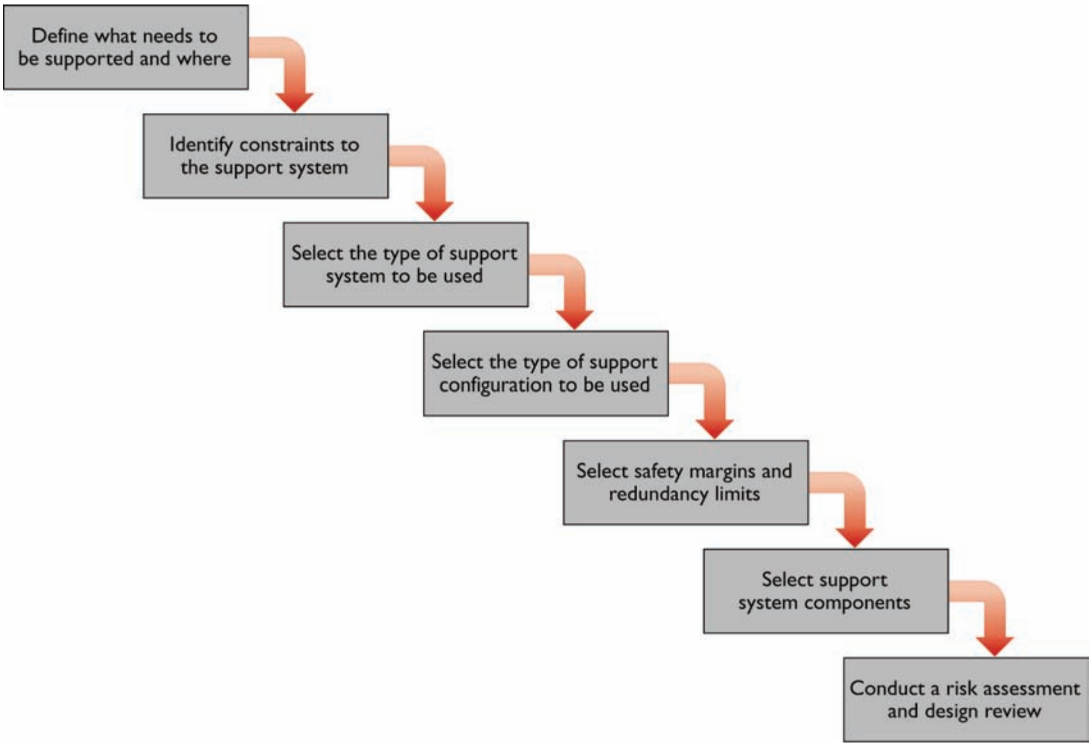


Figure 7: The design process for ductwork support systems. Each of these seven stages is described in more detail in the following sections.

3.1 THE DESIGN PROCESS

Defining what needs to be supported

In order to correctly design and specify ductwork support systems it is essential to have a clear understanding of the load to be supported.

For a simple run of ductwork, all that may be needed is the weight per metre, the duct dimensions and any limits on the spacing of duct supports. It is important to take into account any thermal insulation or protective cladding employed in the ductwork system because this will increase the supported load. Consideration should also be given to any loads that may be applied to structural fixings during the installation of the ductwork system.

For large ducts where access is required for cleaning activities, an allowance should be made for the weight of people and cleaning equipment. In a similar manner, additional supports may be required for items that require periodic maintenance, such as filters.

Specification for Sheet Metal Ductwork DW/144, produced by the Heating and Ventilating Contractors' Association (HVCA) provides guidance on the maximum support spacing for ductwork. The weight of different sizes of rectangular and circular ductwork is provided in Appendix A.

For complex items of plant, such as air handling units or prefabricated services modules, the dimensions, weight, centre of gravity and details of the support attachment points will need to be known.

Careful attention also needs to be paid to the overall strategy for building services supports that are to be built in a traditional manner on site. For example, if a support configuration (such as a simple yoke), is to be employed to support ductwork, pipework and electrical systems, it must be designed to accommodate all these loads, including the water contained in the pipework.

Consideration should also be given to the type of loads that may be applied to the support system. Although most loads in ductwork applications are static, equipment such as fans will create brief dynamic loads, especially during start-up. It is recommended that construction project teams should consult fixing manufacturers for advice about dynamic loading in ductwork systems.

Constraints to the support systems

Constraints imposed on the ductwork support system by the building structure, the ductwork system components being supported, and the operating environment need to be clearly defined.

The structural base materials and permissible fixing points need to be clearly identified. Different materials, such as concrete, steel, timber and masonry, have different load-bearing capacities. Each of these base materials is available in a variety of shapes, sizes and strengths.

Primary structural steel columns and beams are spaced at specific intervals within a building and may have structural fire protection that will affect the ability to attach fixings. Secondary steelwork, such as roof purlins, is spaced at regular intervals, but has very limited load-bearing capacity for the support of services. Composite steel decking is available with different types of re-entrant channel located at uniform intervals. Pre-cast hollow concrete slabs have voids and reinforcing tendons in specific locations. Solid concrete slabs typically contain steel reinforcement or post-tensioning tendons and may contain cracks in working conditions. All these constraints will influence the type of construction fixing that can be used and where it can be located.

The operating environment of the ductwork system is another key consideration in the design of supports. Construction project teams need to clearly identify if the ductwork is installed in areas of high humidity, a corrosive atmosphere, an external location, or in a location subject to wide ranges of temperature. These factors will influence the type of structural fixing that can be used, together with the type of material from which it should be manufactured. Table 1 provides general guidance about support material types in relation to the operating environment.

Table 1: Types of support material for different operating environments.

Operating conditions of the ductwork system	Recommended material for ductwork supports
Dry inside rooms with no condensation	Steel galvanised to a depth of 5-10 microns
Damp inside rooms. Poorly ventilated rooms. Basement shafts. Areas with occasional condensation due to high humidity and fluctuating temperatures	Hot-dipped galvanized steel. A2 stainless steel
Rooms with frequent and long-lasting condensation and where no particularly aggressive conditions exist, such as greenhouses	A4 stainless steel
External atmospheric exposure	A4 stainless steel
Tunnels	Special steel alloys offered by fixing manufacturers. Possibly A4 stainless steel.
Swimming pools	Special steel alloys offered by fixing manufacturers

Fixing manufacturers will provide construction project teams with detailed advice about the types of materials that should be used for ductwork supports in different operating conditions.

Support systems used for fire-rated ductwork must be capable of bearing the load of the ductwork under fire conditions. The element of the building structure to which the support system is connected must have a fire rating of at least that specified for the ductwork, and be able to support the weight of the ductwork under fire conditions.

Support system selection

A wide range of proprietary ductwork support components are available to construction project teams. Threaded rod, profiled channel systems and wire rope are commonly used to configure hanger arrangements. A wide variety of brackets, straps and clips are employed to connect hanger arrangements to the ductwork system components. The provision of detailed information about these elements of a ductwork support assembly is outside the scope of this document. However, detailed product information is provided by leading manufacturers such as Hilti, Gripple, Fischer, ITW and Lindapter.

An enormous variety of anchors, screws, bolts, clamps and wires are available to attach ductwork support assemblies to structural base materials. Information about the selection and installation of these key elements of any ductwork support system is covered later in this guide.

Support configuration

There is a wide range of possible ductwork support configurations available to construction project teams. The chosen configuration will be a function of the particular circumstances of each installation, such as the overall load, the position and characteristics of suitable fixing points on the building structures, and the attachment options of the ductwork system element being supported.

Consideration should also be given to the type of material from which the ductwork system components are manufactured, and whether or not the support system needs to be isolated from these materials.

The design process should seek to provide a support configuration that is simple and quick to install, and meets the requirements for load stability and the requirements for redundancy should part of the support system fail.

Safety margins and redundancy

The integrity of a support system not only depends on the strength and configuration of the supports, but also on the strength and stiffness of the supported load. Stiff loads will tend to successfully transfer loads to a number of adjacent support assemblies, while more flexible loads may only transfer the load to the adjacent support assembly.

If a support system can sustain the failure of a support element and successfully transfer the load to adjacent supports, the support system is said to provide redundancy. The more failures that a support system can sustain, the greater the degree of redundancy. The degree of redundancy required will depend on the risk posed by the failure of the ductwork support system. For light loads, in the order of 1 kN (100 Kg vertically suspended), redundancy can usually be assumed if the load can be transferred to two adjacent fixings in the case of linear system of supports, or three adjacent fixings in the case of a bi-directional system of supports.

Ductwork support components are given a safe working load by their manufacturer. In many applications it will be acceptable to design a ductwork support system that operates at, or just below, this rating. However, there may be circumstances where the risk or consequences of failure requires the support system to be able to cope with other unexpected loads. The safe working load of a ductwork support component may be calculated in a number of ways, but it is typically between a quarter and a fifth of the component's design ultimate tensile strength. This helps provide a margin for any inconsistencies in installation and the normal degradation of the component over its installed life.

Support systems used for fire-rated ductwork must be capable of bearing the load of the ductwork under fire conditions. The standard safe working load of support components with a fire rating is reduced. Manufacturers will be able to provide certified loading data for different exposure times under conditions of standard fire test procedures.

Support system components

Once a ductwork support system configuration has been chosen, the construction project team should determine the load on each individual ductwork support assembly. This will ensure that suitably strong components are specified and that the building structure can withstand the intended loads.

In locations where ductwork components are supported vertically from above, the support elements are subjected to tensile loads in the vertical direction only. However, if ductwork is supported by wire rope installed at an angle, a shear load will be applied to the support assembly and the total load of the support assembly will be higher. This is illustrated in Figure 8 and Table 2 for a 200 kg ductwork system element supported by a pair of wires.

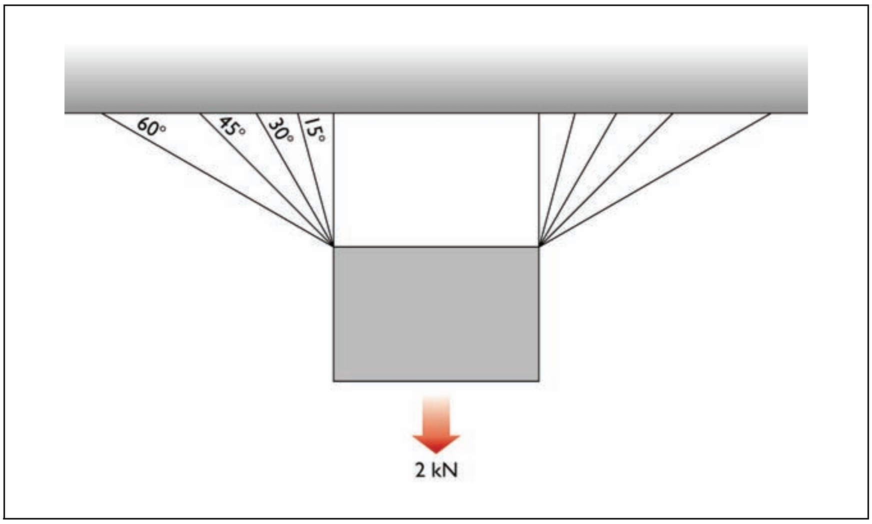


Figure 8: Different angle ductwork support configurations.

Table 2: Loads imposed on ductwork supports installed at different angles.

	Loading of each wire and structural fixing		
Angle from the vertical	**Vertical load**	**Lateral load**	**Total load**
0°	1·00 kN	0·00 kN	1·00 kN
15°	1·00 kN	0·27 kN	1·04 kN
30°	1·00 kN	0·58 kN	1·15 kN
45°	1·00 kN	1·00 kN	1·41 kN
60°	1·00 kN	1·73 kN	2·00 kN

In a similar manner, if a length of vertical ductwork is supported by a horizontal support assembly, as shown in Figure 9, careful attention will need to be paid to determine the tensile and shear loads acting upon the support assembly components. Once the load on each support assembly has been defined, the components of the support can be chosen.

Figure 9: Rectangular ductwork in a vertical riser shaft.

An essential factor to consider when selecting ductwork support components is the safe working load of a component. For a structural fixing such as an expansion anchor, the safe working load will change as a function of the base material to which it is fixed.

It is important to note that ductwork support components with a fire rating have their standard safe working load reduced to ensure that they provide adequate strength in the extreme conditions of a fire.

It is recommended that only components having a European Technical Approval (ETA), CE mark, or testing certificate issued by an approved testing body should be employed to configure a ductwork support system. This applies to ductwork supports in standard applications and fire-rated applications.

It is important to remember that a ductwork support configuration is only as strong as the safe working load of its weakest component.

Risk assessment and design reviews

While construction professionals will be aware of the use of risk assessments during the construction phase of a project, they also need to minimise the risk of the future failure of ductwork support systems.

The risk assessment will need to consider three issues:

- What can fail?
- What are the potential causes of failure?
- What are the consequences of failure?

Risk management is the process of applying the recommendations of the risk assessment to the ductwork support system in order to reduce the risk of injury or damage to an acceptable level. There are three principal approaches that should be applied:

- Remove the hazard: does the ductwork need to be suspended and/or installed in this location?
- Reduce the exposure to the hazard: if the hazard cannot be removed, then it may be possible to limit access to the area beneath high level ductwork, exposing as few people as possible to the hazard
- Reduce the likelihood of failure: use a stronger ductwork support system or increase the number of supports to increase redundancy.

4.1 WORKING PRINCIPLES

In order to correctly select and install a structural fixing for a particular ductwork support application, it is useful to understand the basic working principles of fixings, together with the principal modes of fixing failure.

There are five basic working principles that make the structural fixing of a ductwork support system stay connected to a base material. These principles are described in Table 3 below:

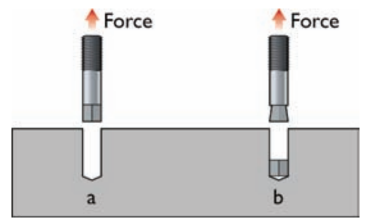
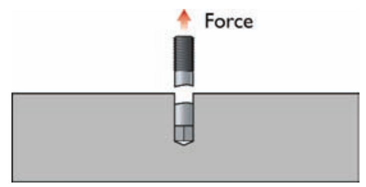
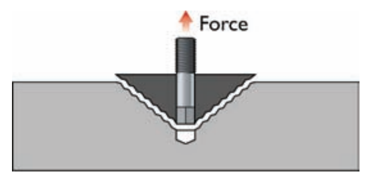
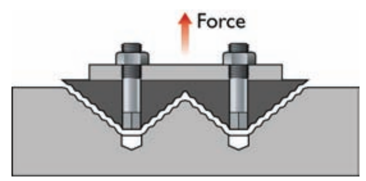
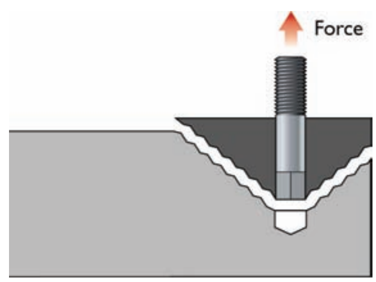
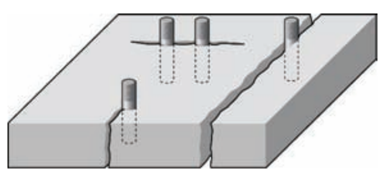
Table 3: Working principles of structural fixings.

Example		Explanation
Friction		Friction is the working principle of expansion anchors. When installing the anchor, an expansion force is created which produces a friction force between the anchor and the structural base material. Two types of expansion anchor can be distinguished: torque-controlled and displacement-controlled. Torque-controlled anchors are expanded by applying a defined torque, which draws a cone into a sleeve and presses the sleeve against the hole wall. Displacement anchors are expanded by driving a cone into the sleeve, thereby pressing it against the wall of the hole. Hole depth, hole diameter and anchor embedment depth are key criteria that affect performance of these fixings.
Keying ***(or mechanical interlock)***		Keying is the working principle of screws and undercut anchors. As a self-tapping concrete screw is driven into a pre-drilled hole, it keys into the structural base material. An undercut anchor keys into the base material as it is tightened to a specified torque. Hole depth, hole diameter and anchor embedment depth are key criteria that affect performance of these fixings. Keying is also one of the key working principles of direct fastening systems, which drive hardened nails into the structural base material using specialist power tools. Direct fastening also uses bonding and clamping principles too.
Bonding		Bonding is the working principle of adhesive anchors. An adhesive bond is formed between the metal anchor and the hole wall by a synthetic resin. The curing of the resin is characterised by two critical times: Gel (or open) time: The time from the end of mixing to when the insertion of the anchor into the bonding materials should take place. Curing time: The minimum time from the end of mixing to when the anchor may be torqued or loaded. In addition to hole depth, hole diameter and anchor embedment depth, hole cleanliness is a key criteria that affects performance of these fixings.
Clamping		Clamping occurs when forces are applied to opposing faces of a base material. In the case of a beam clamp, this creates friction and sometimes keying between the jaws or set screw of its clamp and the structural member being sandwiched. This is the operating principle of dovetail wedges used in re-entrant channels and T-head bolts used in cast-in channel systems. Tightening of the clamps to the correct torque is crucial to correct performance of these devices, as is the correct orientation of the clamps, wedges and T-head bolts.
Looping		Looping occurs when a support element, such as steel wire rope, is passed through or around a structural member such as a beam, purlin or roof truss, and then passed back though a pre-formed loop in the wire.

4.2 PRINCIPAL MODES OF FAILURE

In order to ensure that structural fixings for ductwork systems are correctly selected and installed, it is important to understand the principal ways in which structural fixings fail. The principal failure modes of structural fixings are shown in Table 4 below.

Table 4: Principal modes of failure of structural fixings.

Examples		Explanation
Pull-out failure and pull through failure		In pull-out failure (a), the fixing is withdrawn from the structural base material. This occurs where the friction, keying or bonding force exerted by the anchor in the base material is too low to keep the fixing in position when it is placed under load. In pull-through failure (b), the cone, cone bolt of threaded attachment are pulled out of the fixing body, which remains in the base material.
Fixing component failure		Fixing component failure occurs when the strength of the components from which the fixing is composed is unable to withstand the supported load.
Cone and edge failure of base material		Expansion and undercut anchors produce a conical stress zone beginning in the area of expansion or undercut of the fixing. Cone failure of the base material occurs when the base material is unable to withstand the force created by an expansion anchor or an undercut anchor. The spacing of adjacent fixings may lead to overlapping of conical stress zones. This is why care needs to be taken when spacing adjacent fixings. Edge failure of the base material occurs when the base material is unable to withstand the force created by an expansion anchor or an undercut anchor. Great care also needs to be taken to ensure that any type of anchor subject to shear loads is not placed too near the edge of the base material.
Splitting failure of base material		In splitting failure, splitting may lead to a complete split of the structural base material, cracks between fixings, or cracks between fixings and the edge of the base material. This type of failure occurs when the dimensions of the base material are too small and/or the distance between fixings or between fixings and the edge of the base material is too small.

The leading manufacturers of structural fixings provide technical data and software design solutions that enable the performance of fixings to be determined in conditions where edge distances and spacing influence the performance or fixings.

The component that attaches to the structure is one of the three key elements of a ductwork support assembly. The support assembly is also composed of a hanger arrangement and an element that attaches to the ductwork component. Figure 10 shows rectangular ductwork suspended from a concrete slab by a support composed of a concrete anchor, a threaded rod hanger and an angled bracket connected to the duct.

Figure 10: Rectangular ductwork suspended below a concrete slab.

Construction project teams often find it difficult to determine a suitable structural fixing for a particular ductwork support application. In addition, once fixings have been selected, project personnel do not always understand the key installation procedures for these components.

The aim of this chapter is to assist project personnel with the selection and installation of structural fixings for ductwork supports. The guidance covers each of the following structural base materials:

- Concrete
- Hollowcore concrete
- Composite decking
- Steelwork
- Masonry
- Timber.

Note that installation work should be performed by competent site personnel, under proper supervision.

5.1 FIXINGS IN SOLID CONCRETE

Concrete is a synthetic stone consisting of a mixture of cement, aggregates and water, which is produced when the cement paste hardens and cures. In lightweight concrete, the aggregate typically used for normal concrete, such as crushed stone, is substituted with lighter materials such as pulverised fuel ash. This reduces the concrete's compressive strength.

Concrete strength is denoted by a capital letter C and two further numbers. For example a concrete classified as strength C20/25 will have a compressive strength of 20 N/mm^2, measured in cylinders of 150 mm diameter and 300 mm height, and 25 N/mm^2, measured in a 150 mm cube.

Concrete has a high compressive strength, but only a low tensile strength. Steel reinforcing bars or post-tensioning tendons are cast into concrete to take up tensile forces. It is then referred to as reinforced concrete.

A reinforced concrete structure will have cracks in it under working conditions. However, provided that the cracks do not exceed a certain width, it is not necessary to regard these cracks as defects. Structural designers assume that cracks will exist in the tension zone of a reinforced concrete structure. Figure 11 illustrates typical crack locations for a simple concrete structure under a uniformly distributed load.

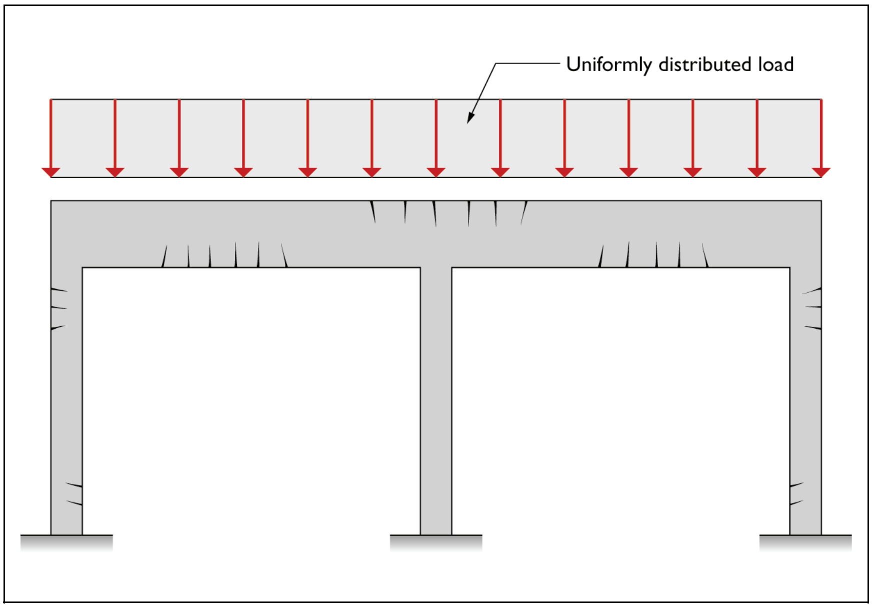


Figure 11: Crack locations for a simple concrete structure.

When selecting fixings for concrete structures, construction project teams should determine if the fixings are located in cracked or un-cracked zones of the structure. They should also check that cracks are usable at the time that fixings are installed; cracks less than a certain width do not represent a failure of the structure, but they may reduce fixing performance.

On some projects, rolled steel channels are cast into concrete slabs to provide fixings points to the structure. The channels are rectangular in section and are bonded to the concrete by anchors.

Figure 12 shows this embedded channel system. Matching T-head bolts for each channel profile are used to fix ductwork and other building services elements in position.

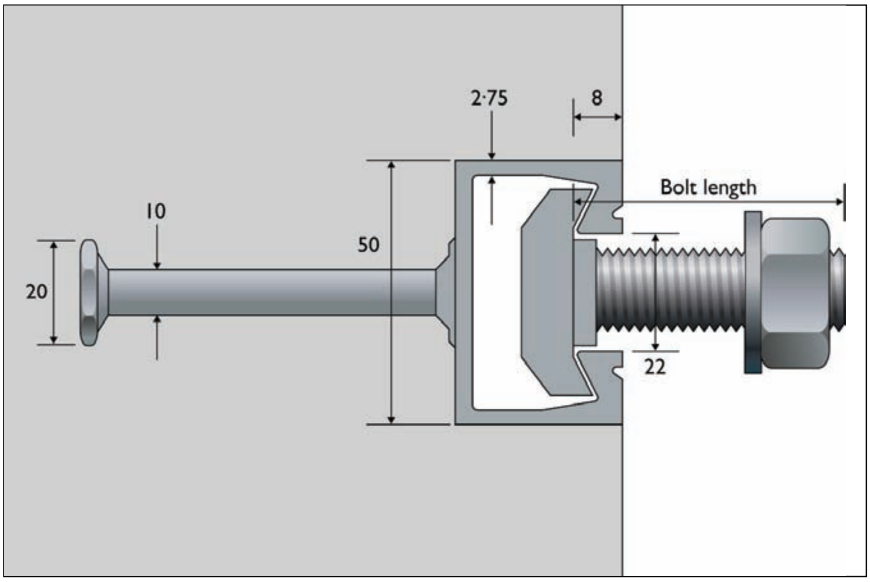


Figure 12: An embedded channel support system.

Smooth-lipped channels and toothed-lipped channels are available. The toothed-lipped channels are recommended for longitudinal loads.

Table 5 on the following page shows types of fixings that are suitable for use in the support of ductwork systems from solid concrete slabs. For each type of fixing, a typical range of safe working loads is given.

Please note that these figures are for guidance purposes only and that fixing manufacturers should always be consulted for advice in relation to the specific needs of a construction project. Leading fixing manufacturers have extensive data about the performance of approved anchors in concrete. They can also assist with pull-out tests to validate the performance of fixings in actual project conditions.

The figures shown in Table 5 are given for fixings having the manufacturer's recommended embedment depth, without influence of neighbouring anchors and concrete edges, and in non fire-rated applications.

Table 6 on page 17 highlights some of the key things that construction project teams need to consider when selecting and installing fixings in solid concrete.

Table 5: Structural fixings for use in solid concrete.

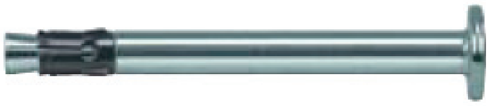
Type of fixing for use in solid concrete		**Typical range of tensile safe working loads (Kg)**
Stud anchor		200 Kg (8 mm diameter) 430 Kg (10 mm diameter) 570 Kg (12 mm diameter) Figures given for Hilti HST stud anchor in cracked concrete. Anchors with higher load capacities are available
Knock-in (or drop-in) anchor		200 Kg (8 mm internal thread x 40 mm) 240 Kg (10 mm internal thread x 40 mm) 240 Kg (12 mm internal thread x 50 mm) Figures given for Hilti HKD anchor in a redundant-fastening application in cracked concrete
Sleeve anchor		140 Kg (8 mm diameter) 180 Kg (10 mm diameter) 290 Kg (12 mm diameter) Figures given for Hilti HLC anchor in uncracked concrete
Wedge anchor		160 Kg (8 mm diameter) Figure given for Hilti DBZ anchor in anchor in a redundant-fastening application in cracked concrete
Nail anchor		110 Kg (6 mm diameter) Figure given for Fischer FNA II anchor in uncracked C20/25 concrete
Screw anchor		200 Kg (10·5 mm diameter screw) 300 Kg (12·5 mm diameter screw) Figures given for Hilti HUS-H in cracked concrete
Powder or gas actuated fixing ***(Sometimes called direct fastening)***		40 Kg (without pre-drilled hole) 90 Kg (with pre-drilled hole) Figures given for the Hilti direct fastening range of products
Cast-in channel with T-Bolt		350 - 800 Kg (M10 T-head bolts) 600 - 1400 Kg (M12 T-head bolts) Figures given for Halfen HTA channel and T-head bolts. The more anchors in a given length of embedded channel, the greater the load it can support

Table 6: Checklist for the selection and installation of fixings in solid concrete.

Checklist item	Guidance notes	Initial and date
What is the size and nature of the load acting on the structural fixing?	Is it purely a tensile load? Is there a shear load or bending moment that needs to be considered? Is it a dynamic load?	
What is the strength of the concrete into which the fixing is being made?	The concrete strength will be defined in the structural specification for the project.	
What is the depth of the concrete into which the fixing is being made?	As a guide, the minimum concrete thickness should be the hole depth plus two times the anchor depth.	
Is the fixing being made into cracked or un-cracked concrete?	The project structural engineer should be consulted about this.	
What is the operating environment of the structural fixing?	Is the ductwork installed in a dry internal environment, an area of high humidity, a corrosive atmosphere, an external location, or in a location subject to wide ranges of temperature, for example.	
Does the structural fixing need to have a fire rating?	Support systems used for fire-rated ductwork must be capable of bearing the load of the ductwork under fire conditions.	
If the ductwork system component is fixed against the face of the concrete, has the thickness of its fixing bracket been taken into account when selecting fixings?	Adequate embedment depth is crucial for the effective functioning of an anchor. The thickness of the item being fixed against the face of the concrete therefore needs to be taken into account when selecting anchors.	
Is the spacing distance between fixings in accordance with the fixing manufacturer's recommendations?	As a guide, the spacing between fixings should be three times the anchor length.	
Is the spacing distance between a fixing and the edge of the concrete in accordance with the fixing manufacturer's recommendations?	As a guide, the minimum edge spacing should be three times the anchor length.	
Does the fixing that has been chosen have a European Technical Approval (ETA) or other independent test certification that validates its performance?	It is recommended that the performance of a structural fixing is validated by an independent test body.	
Has the concrete been allowed to cure before installation of the structural fixing takes place?	Expansion anchors should not be set in concrete that has not cured for more than seven days. If anchors are loaded immediately after being fixed in place, the loading capacity can only be assumed to be the strength of the concrete at that time.	
Is the location of reinforcement bars or post-tensioning tendons known?	The embedment depth of an anchor should not be reduced because reinforcement is in the way. Rather, the anchor should be relocated.	
What setting is required on the drill or direct-fastening tool for this fixing?	Is a hammer drill or rotary drill setting recommended? What drill speed does the manufacturer recommend? What setting is recommended for the powder or gas-actuated direct fastening power tool? Trial fixings may be required to establish settings.	
What diameter hole needs to be drilled for this fixing?	The manufacturer will provide details about the specific hole diameter that needs to be drilled for a particular anchor.	
What depth of hole needs to be drilled for this fixing?	The manufacturer will provide details about the specific hole depth that needs to be drilled for a particular anchor.	
Is a brush and air pump available to clean out the drilled hole?	Hole cleaning is recommended for every type of anchor, but is essential for adhesive fixings.	
What is the correct setting procedure and correct setting equipment required for this fixing?	It is essential that the setting procedure defined by the manufacturer is followed and that the correct setting equipment is used.	
What torque setting is required for this fitting?	Note that the tightening torque for a fixing is usually specified for normal strength concrete. If a fixing is used in lightweight concrete, the torque may need to be reduced in relation to the permissible load-bearing capacity of this base material.	
Has the thread of a drop rod or fixing bolt been properly engaged?	Adequate thread engagement is essential to ensure that safe working loads of fixings can be achieved. Nine full turns, when inserting bolts and threaded rods, will ensure an engagement of the minimum required length.	

5.2 FIXINGS IN HOLLOWCORE CONCRETE

Hollowcore concrete floor slabs are composed of pre-stressed concrete units that feature a series of voids that run the length of each unit. A variety of void profiles are available.

Figure 13 is a cross-sectional image of a hollowcore concrete slab. It shows the voids and the post-tensioning tendons.

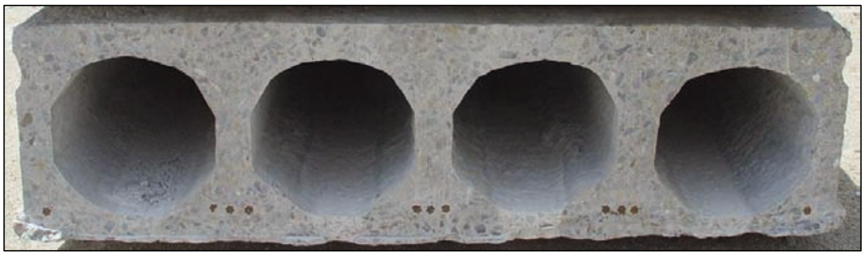


Figure 13: A cross-section of a hollowcore concrete slab showing four voids and three sets of post-tensioning tendons.

Great care needs to be taken when attaching fixings to hollowcore concrete slabs to ensure that the pre-stressing tendons are not damaged.

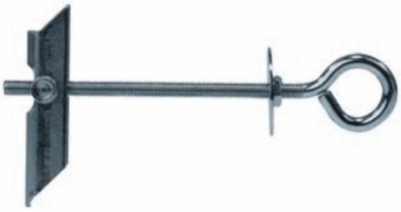
Flared-end anchors, toggle fixings, self-tapping concrete screws and adhesive anchors can be used in the areas of the slab where the voids are located. If self-tapping screws are used, a small diameter pilot hole must be drilled into the slab void.

Figure 14: Flare-end anchors used in hollowcore concrete slab.

Advice should be sought from both the concrete slab manufacturer and the fixing manufacturer before fixing into hollowcore concrete slabs.

The following table shows types of fixings that are suitable for use in the support of ductwork systems from hollowcore concrete slabs. Note that these figures are for guidance purposes only and that fixing manufacturers should always been consulted for advice in relation to the specific needs of a construction project. Fixing manufacturers may be able to assist with pull-out tests to validate the performance of fixings in actual project conditions.

Table 7: Structural fixings for use in hollowcore concrete.

Type of fixing for use in hollowcore concrete slabs		Typical range of tensile safe working loads (Kg)
Flared end expansion anchor		250 Kg Figure given for an M10 Fischer FHY expansion anchor
Hollow deck anchor		90 Kg (cavity to surface depth 25 mm) 120 Kg (cavity to surface depth 30 mm) 300 Kg (cavity to surface depth 40 mm) Figures given for an M10 Hilti HKH hollow deck anchor
Glass reinforced nylon anchor with brass cone		150 Kg (10 mm diameter internal thread) Figure given for an M10 Fischer M unit expansion anchor
Screw anchor		200 Kg (7·5 mm diameter screw) Figure given for Fischer FFS self-tapping screw with a 6 mm diameter pilot hole.
Toggle fixing		300 Kg Figure given for Fischer KD 8 gravity toggle
Adhesive anchor		645 Kg (10 mm diameter stud) Figures given for the Fischer FISV 360 S Injection Resin with anchor sleeve

The figures shown in Table 7 are given for fixings without influence of neighbouring anchors and concrete edges, and for non fire-rated applications.

Table 8 on the following page highlights some of the key issues that construction project teams need to consider when selecting and installing fixings in hollowcore concrete slabs.

Table 8: Checklist for the selection and installation of fixings in hollowcore concrete slabs.

Checklist item	**Guidance notes**	**Initial and date**
What is the size and nature of the load acting on the structural fixing?	Is it purely a tensile load? Is there a shear load or bending moment that needs to be considered? Is it a dynamic load?	
What is the strength of the concrete into which the fixing is being made?	The concrete strength will be defined in the structural specification for the project.	
Are the locations and dimensions of the concrete voids clearly understood?	These criteria need to be known in order to correctly position fixings.	
What is the distance between the surface of the concrete and concrete voids?	Embedment depth is a crucial factor in fixing performance, so it is essential that this distance is known. This depth also needs to be maintained through good workmanship.	
Is the location and depth of the post-tensioning tendons known?	It is essential that reinforcement tendons are not damaged by construction fixings because this will affect the structural integrity of a hollow concrete slab.	
What is the operating environment of the structural fixing?	Is the ductwork installed in a dry internal environment, an area of high humidity, a corrosive atmosphere, an external location, or in a location subject to wide ranges of temperature?	
Does the structural fixing need to have a fire rating?	Support systems used for fire-rated ductwork must be capable of bearing the load of the ductwork under fire conditions.	
If the ductwork system component is fixed against the face of the concrete, has the thickness of its fixing bracket been taken into account when fixings are selected?	Adequate embedment depth is crucial for the effective functioning of an anchor. The thickness of the item being fixed against the face of the concrete therefore needs to be taken into account when anchors are selected.	
Is the spacing distance between fixings in accordance with the fixing manufacturer's recommendations?	As a guide, the minimum spacing between fixings should be three times the anchor length.	
Is the spacing distance between a fixing and the edge of the concrete in accordance with the fixing manufacturer's recommendations?	As a guide, the minimum edge spacing should be three times the anchor length.	
Does the fixing have an approval for use by the manufacturer of the hollowcore concrete floor slab?	Leading manufacturers of hollowcore slabs, such as Bison, have conducted tests on a wide range of construction fixings.	
Does the chosen fixing have a European Technical Approval (ETA) or other independent test certification that validates its performance?	It is recommended that the performance of a structural fixing is validated by an independent test body.	
What setting is required on the drill tool for this fixing?	Is a hammer drill or rotary drill setting recommended? What drill speed does the manufacturer recommend? Trial fixings may be required to establish settings.	
What diameter hole needs to be drilled for this fixing?	The manufacturer will provide details about the specific hole diameter that needs to be drilled for a particular anchor.	
Is a brush and air pump available to clean out the drilled hole?	Hole cleaning is recommended for every type of anchor, but is essential for adhesive fixings.	
What is the correct setting procedure and correct setting equipment required for this fixing?	It is essential that the setting procedure defined by the manufacturer is followed and that the correct setting equipment is used.	
What torque setting is required for this fitting?	The tightening torque for a fixing is usually specified for normal strength, solid concrete. The fixing manufacturer may recommend a lower torque setting for hollow concrete slabs.	
Has the thread of a drop rod or fixing bolt been properly engaged?	Adequate thread engagement is essential to ensure that safe working loads of fixings can be achieved. Nine full turns, when inserting bolts and threaded rods, will ensure an engagement of the minimum required length.	

5.3 FIXINGS TO COMPOSITE DECKING

A composite deck is a concrete slab where a profiled steel deck is employed as a permanent shuttering system. The steel profile acts as all, or part, of the tensile bottom reinforcement for the concrete slab.

Many steel decking profiles have re-entrant slots into which wedge-shaped mechanical fixings can be inserted. This is illustrated in Figure 15.

It is important to understand that specific wedge-shaped fixings are required for the re-entrant slots of the different profiled decking systems. A selection of different decking profiles and fixings is shown in Table 9.

Figure 15: A cross-section of a composite concrete deck.

Table 9: Examples of different decking profiles and wedge-shaped fixings.

Examples of different types of decking profile	Examples of different types of wedge-shaped fixings
  	    

Concrete anchors and powder-actuated fastenings can also be employed on composite decks. The metal profile needs to be considered in the selection of drill bits and drill settings and in the selection of the appropriate cartridge and power settings of the direct fastening system.

If concrete anchors, self-tapping concrete screws or powder-actuated fastenings are employed for a composite deck, then designers should use the checklist and fixing selection guide used in section 5.1.

Table 10 shows types of wedge-shaped fixings that are suitable for use in the support of ductwork systems from composite decks. A typical range of safe working loads is given. Note that these figures are for guidance purposes only and that fixing manufacturers should always be consulted for advice in relation to the specific needs of the construction project.

The figures shown in the Table 10 are for fixings for non fire-rated applications.

The checklist shown in Table 11 highlights some of the key issues that construction project teams need to consider when selecting and installing re-entrant slot fixings in composite decking.

Table 10: Wedge-shaped fixings for use in composite decking.

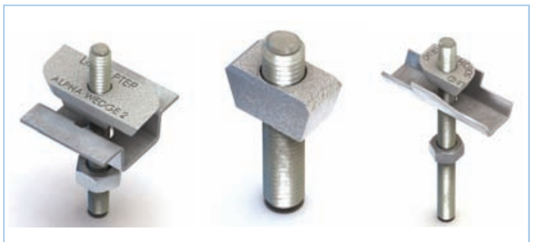
Type of fixing for use in composite decking		Typical range of tensile safe working loads (Kg)
Wedge fixing		100 to 150 Kg This safe working load range relates to wedge-shaped fixings used in the Richard Lees Steel Decking range of composite deck profiles

Table 11: Checklist for the selection and installation of fixings to composite decking.

Checklist item	**Guidance notes**	**Initial and date**
What is the size and nature of the load acting on the structural fixing?	Is it purely a tensile load? Is there a shear load or bending moment that needs to be considered? Is it a dynamic load?	
What is the strength of the concrete into which the fixing is being made?	The concrete strength will be defined in the structural specification for the project.	
What wedge-shaped fixings does the steel decking manufacturer recommend for use in the composite deck's re-entrant slots?	It is essential that the wedge-shaped fixings are compatible with the re-entrant slots of the steel decking. Richard Lees Steel Decking will supply fixings embossed with the type of deck to which they are suitable.	
Does the fixing that has been chosen have a European Technical Approval (ETA) or other independent test certification that validates its performance?	It is recommended that the performance of a structural fixing is validated by an independent test body.	
Has the concrete been allowed to cure before wedge-shaped fixings are attached to the composite deck?	Advice should be sought from the project structural engineer about when wedge-shaped fixings can be attached to the profiled deck.	
Has the insertion of wedge-shaped fittings into lap joints in the steel decking been avoided?	Wedge-shaped fittings should not be inserted into lap joints in the steel decking profile because the lap joint may affect the connection between the re-entrant channel and the wedge fitting.	
What is the setting procedure for the specific wedge-shaped fixing being used?	It is recommended that the setting procedure defined by the manufacturer is followed.	
What torque setting is required for the wedge-shaped fitting?	The tightening torque varies for different types of re-entrant slot fixings. The strength of the concrete used in the composite deck will also influence the required torque.	

5.4 FIXINGS FOR STEELWORK

For the purpose of this guide, steelwork is divided into two categories: primary steelwork and secondary steelwork.

Primary steelwork is the term used to describe the main structural columns and beams. Figure 16 shows the installation of building services on a construction project that has employed cellular beams. Other steel beam varieties, such as stub girders, castellated beams, tapered beams and notched beams also provide alternative design options for construction project teams.

Secondary steelwork is the term used to describe steelwork made from light gauge steel, such as roof purlins, façade side rails and metal framing systems.

Figure 17 shows profiled steel roof purlins which are 170 mm deep.

Figure 16: The ceiling void of an office development.

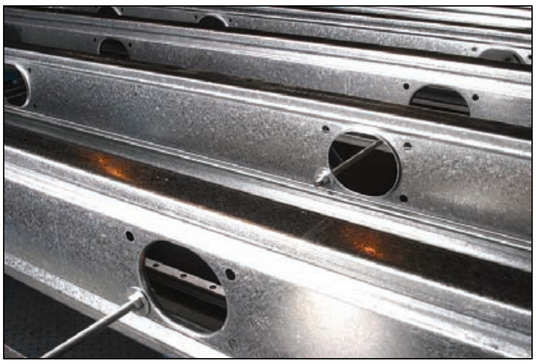


Figure 17: A roof system employing profiled steel purlins.

A wide range of profiled secondary steelwork profiles are available for use by construction project teams. Some examples are shown in Figure 18.

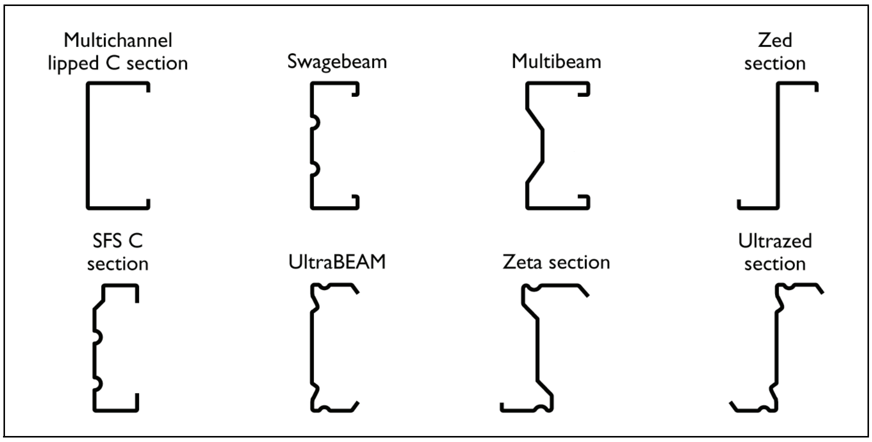
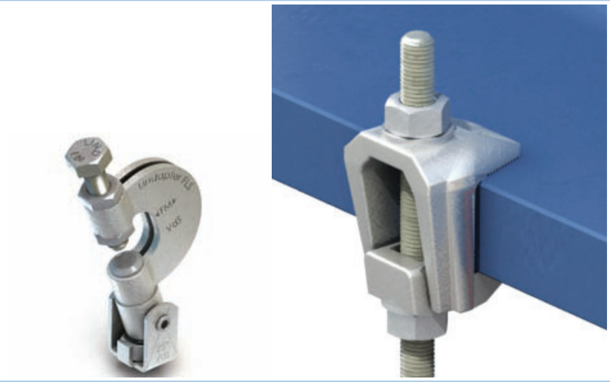
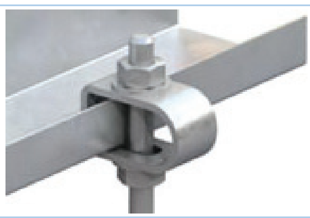


Figure 18: Different types of secondary steelwork profiles.

Table 12 on the following page shows types of fixings that are suitable for use in the support of ductwork systems from steelwork. A typical range of safe working loads is given for each type of fixing. Note that these figures are for guidance purposes only and that fixing manufacturers should always been consulted for advice in relation to the specific needs of a construction project. Fixing manufacturers may be able to assist with pull-out tests to validate the performance of fixings in actual project conditions.

Figures shown in Table 12 are given for fixings in non fire-rated applications.

Table 12: Structural fixings for use with steelwork.

Type of fixing for use with steelwork		Typical range of tensile safe working loads (Kg)
Beam clamp		90 to 310 Kg Figures are taken from the Lindapter F3, FL, FLS and F3-BICC range of beam clamps up to M12 thread size. Clamps using larger thread sizes are available.
Purlin clamp		15 Kg This is the average safe working load of the Lindapter Z10 purlin clamp across a range of purlin profiles.
Purlin web fixing		100 Kg This is the safe working load of the Lindapter WF web fixing.
Wrap-around purlin hanger		75 Kg This is the safe working load of the Lindapter HCW 34 wrap-around purlin hanger.
Powder actuated fixing		100 Kg (for 1 mm thick steel being fixed in place) 150 Kg (for 1·5 mm thick steel being fixed in place) Figures given for the Hilti direct fastening range of fixings. The installation method and the required minimum number of fixings per support location should be verified with Hilti.
Loop-end steel wire		90 Kg (No. 3 wire) 225 Kg (No. 4 wire) 325 Kg (No. 5 wire) Figures given for the Gripple loop-end fixing range of wire ropes.

The following checklist highlights some of the key issues construction project teams need to consider when selecting and installing fixings for steelwork.

Table 13: Checklist for the selection and installation of fixings for steelwork.

Checklist item	Guidance notes	Initial and date
What is the size and nature of the load acting on the structural fixing?	Is it purely a tensile load? Is there a shear load or bending moment that needs to be considered? Is it a dynamic load?	
What is the strength of the steelwork on to which the fixing is being made?	The project structural engineer and the manufacturers of profiled secondary steelwork should be consulted about this.	
What is the thickness of the beam flange on to which the fixing is being made?	The flange thickness will affect the type of clamp or powder-actuated fixing that can be used.	
Is the beam flange on to which the fixing is being made of parallel thickness or is it tapered?	The setscrew of a beam clamp should always be tightened on to the tapered face of a flange.	
Is the steelwork on to which the fixing is being made horizontal or is it inclined?	If the steelwork is inclined, this will influence the choice of beam clamp and the design of the ductwork support.	
Is the purlin fixing compatible with the particular profiles of secondary steelwork that are being used?	A wide range of purlin profiles is available. The fixing supplier should be consulted to make sure that the appropriate fixing type is selected.	
What is the operating environment of the structural fixing?	Is the ductwork installed in a dry internal environment, an area of high humidity, a corrosive atmosphere, an external location, or in a location subject to wide ranges of temperature.	
Does the structural fixing need to have a fire rating?	Support systems used for fire rated ductwork must be capable of bearing the load of the ductwork under fire conditions.	
Does the fixing that has been chosen have a European Technical Approval (ETA) or other independent test certification that validates its performance?	It is recommended that the performance of a structural fixing is validated by an independent test body.	
What orientations are allowed for the beam clamps being used?	A beam clamp will be approved for use in specific orientations. It is essential that only approved orientations are used. The setscrew of a beam clamp should always be tightened on to the tapered face of a flange.	
What torque setting is required for the set-screw of beam clamps and purlin clamps?	In order for a clamp to function as designed, it is essential that it is tightened to the correct torque.	
What type of cartridge is required for the direct-fastening fixing?	The type of cartridge required will be influenced by the strength and depth of the steel into which it is being fixed.	
What setting is required on the direct-fastening tool for this fixing?	What setting is recommended for the powder-actuated or gas-actuated direct fastening power tool? Trial fixings may be required to establish settings.	
Has the correct diameter wire been selected for the load being supported?	Five different diameters of steel wire are produced by Gripple, for example. It is essential that the correct size wire is used.	
Has the thread of a drop rod or fixing bolt been properly engaged?	Adequate thread engagement is essential to ensure that safe working loads of fixings can be achieved. When inserting bolts and threaded rods, nine full turns will ensure an engagement of the minimum required length.	
Has the lock-nut of the drop rod or fixing bolt attached to a clamp been correctly torqued?	It is essential that the tightening torques follow the clamp manufacturer's recommendations.	

5.5 FIXINGS FOR MASONRY

Masonry is the term used to describe a composite of blocks and mortar. The compressive strength of the blocks is usually higher than that of the mortar. There is a wide range variety of types and shapes of masonry block. They can be broadly split into four categories as shown in Figures 19 to 22.

Figure 19: Solid blocks with dense structure, such as clay bricks, sand-lime bricks or natural stone.

Figure 20: Solid blocks with porous structure, such as lightweight concrete blocks and Y-tong panels.

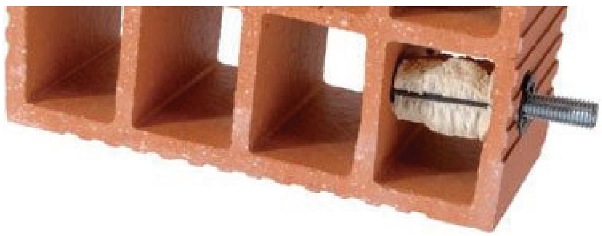
Figure 21: Perforated blocks with dense structure.

Figure 22: Perforated blocks with porous structure.

Table 14 shows types of fixings that are suitable for use in the support of ductwork systems from masonry. A typical range of safe working loads is given for each type of fixing.

Note that these figures are for guidance purposes only and that fixing manufacturers should always been consulted for advice in relation to the specific needs of a construction project. Fixing manufacturers may be able to assist with pull-out tests to validate the performance of fixings in actual project conditions.

Table 14: Structural fixings for use in masonry.

Type of fixing for use in masonry		Typical range of tensile safe working loads (Kg)
Sleeve anchor		60 Kg (M10 anchor in 12 N/mm² solid clay brick) 60 Kg (M10 anchor in 12 N/mm² solid sand lime brick) Figures given for Hilti HLC sleeve anchor.
7·5 mm diameter screw anchor		20 Kg (12 N/mm² solid clay brick) 10 Kg (12 N/mm² hollow clay brick) 20 Kg (6 N/mm² aerated concrete) Figures given for Hilti HUS 7·5 screw anchor
10·5 mm diameter screw anchor		100 Kg (12 N/mm² solid clay brick) 60 Kg (12 N/mm² solid sand lime brick) 20 Kg (6 N/mm² aerated concrete) Figures given for Hilti HUS screw anchor.
Adhesive anchor		300 Kg (M10 anchor in 16 N/mm² brick) 250 Kg (M10 anchor in 14 N/mm² dense concrete block) 150 Kg (M10 anchor in 6 N/mm² lightweight concrete block) 80 Kg (M10 anchor in 7 N/mm² hollow concrete block) The above figures are given for the Hilti HIT-HY 70 injection system with a setting depth of 80 mm.
Nylon plug		120 Kg (12 N/mm² solid clay brick) 120 Kg (12 N/mm² solid sand lime brick) 20 Kg (6 N/mm² aerated concrete) Figures given for the Fischer SX10 nylon plug with 8 mm x 80 mm diameter wood screw

The figures shown in the above table are given for fixings having the manufacturer's recommended embedment depth, without influence of neighbouring anchors and masonry edges, and in non fire-rated applications.

The following checklist highlights some of the key issues that construction project teams need to consider when selecting and installing fixings for masonry.

Table 15: Checklist for the selection and installation of fixings for masonry.

Checklist item	Guidance notes	Initial and date
What is the size and nature of the load acting on the structural fixing?	Is it purely a tensile load? Is there a shear load or bending moment that needs to be considered? Is it a dynamic load?	
What is the strength of the masonry into which the fixing is being made?	The masonry strength will be defined in the structural and architectural specifications for the project.	
Are the locations and dimensions of the voids in any masonry products clearly understood?	These criteria need to be known in order to correctly position fixings.	
What is the operating environment of the structural fixing?	Is the ductwork installed in a dry internal environment, an area of high humidity, a corrosive atmosphere, an external location, or in a location subject to wide ranges of temperature, for example.	
Does the structural fixing need to have a fire rating?	Support systems used for fire rated ductwork must be capable of bearing the load of the ductwork under fire conditions.	
If the ductwork system component is fixed against the face of the masonry, has the thickness of its fixing bracket been taken into account when selecting fixings?	Adequate embedment depth is crucial for the effective functioning of an anchor. The thickness of the item being fixed against the face of the masonry therefore needs to be taken into account when selecting anchors.	
Is the spacing distance between fixings in accordance with the fixing manufacturers recommendations?	Fixing manufacturers provide detailed guidance about the spacing distances of fixings in masonry.	
Is the spacing distance between a fixing and the edge of the masonry in accordance with the fixing manufacturers recommendations?	Fixing manufacturers provide detailed guidance about the positioning of fixings in masonry.	
Does the fixing that has been chosen have a European Technical Approval (ETA) or other independent test certification that validates its performance?	It is recommended that the performance of a structural fixing is validated by an independent test body.	
Do you know what setting is required on the drill tool when installing this fixing in specific masonry products?	Is a hammer drill or rotary drill setting recommended? What drill speed does the manufacturer recommend?	
Do you know what diameter hole needs to be drilled for this fixing?	The manufacturer will provide guidance about the specific hole diameter that needs to be drilled for a particular anchor.	
Do you have a brush and air pump to clean out the drilled hole?	Hole cleaning is recommended for every type of anchor, but is essential for adhesive fixings.	
Do you know the correct setting procedure and have the correct setting equipment required for this fixing?	It is essential that the setting procedure defined by the manufacturer is followed and that the correct setting equipment is used.	
Do you know what torque setting is required for this fitting?	Note that the tightening torque for a fixing is usually specified for normal strength, solid concrete. The fixing manufacturer may recommend a lower torque setting for masonry.	

5.6 FIXINGS IN TIMBER

Timber used in construction can be divided into two categories: solid timber and engineered timber. Engineered timber refers to timber that has been built-up by gluing together smaller pieces of timber. Sawdust and fibre-based materials are used in MDF and hardboard. Veneers are peeled from trunks and glued together to form plywood.

Laminates, such as glue laminated timber, often referred to as glulam, is made by gluing together laminates, typically 50 mm thick and several metres long. A glulam beam is shown in Figure 23.

Figure 23: A glulam roof beam.

The strength, appearance and durability of solid timber all depend on the species of tree and where it was grown. Slow growing trees from cold climates have the slowest growth rates and hence, denser, stronger and more durable wood. A frame constructed from solid timber is shown in Figure 24.

Figure 24: An oak frame for a building.

Timber, as a natural material, is inherently variable, even within a single species. Strength grading of timber helps overcome this variability by assessing the strength and stiffness of timber and assigning them to a strength class that has known and dependable mechanical properties.

A strength class is simply a group of species or strength grade combinations which have similar properties. Solid timber strength classes are defined in *BS EN 338: 2003 Structural Timber Strength Classes*. Eighteen strength classes are defined: 12 for softwood prefixed C and six for hardwood prefixed D.

There are also Glulam strength classes prefixed GL that are defined in *BS EN 1194: 1999 Timber Structures. Glued Laminated Timber. Strength Classes and Determination of Characteristic Values*.

Timber is a convenient material for the fixing of ductwork. Unlike steel and concrete, it can be easily drilled using simple tools. Solid timber or engineered timber beams also do not have not reinforcement or voids that complicate the fixing process.

Table 16 shows the types of fixings that are suitable for the support of ductwork systems for timber. A typical range of safe working loads is given for each type of fixing. Note that these figures are for guidance purposes only.

The Timber Research and Development Association (TRADA) and/or fixing manufacturers should always been consulted for advice in relation to the specific needs of a construction project. Fixing manufacturers may be able to assist with pull-out tests to validate the performance of fixings in actual project conditions.

Table 17 highlights some of the key issues that construction project teams need to consider when selecting and installing fixings for timber.

Table 16: Structural fixings for use in timber.

Type of fixing for use in timber		Typical range of shear safe working loads (Kg)
Coach screw		45 - 85kg
Coach bolt		Obtain advice from TRADA about bolt-through applications
Self-tapping screw		50kg

Table 17: Checklist for the selection and installation of fixings in timber.

Checklist item	Guidance notes	Initial and date
What is the size and nature of the load acting on the structural fixing?	Is it purely a tensile load? Is there a shear load that needs to be considered? Is it a dynamic load?	
What is the strength of the timber into which the fixing is being made?	The strength of any structural solid timber or engineered timber will be defined in the structural specification for the project.	
What is the operating environment of the structural fixing?	Is the ductwork installed in a dry internal environment, an area of high humidity, a corrosive atmosphere, an external location, or in a location subject to wide ranges of temperature.	
Does the structural fixing need to have a fire rating?	Support systems used for fire rated ductwork must be capable of bearing the load of the ductwork under fire conditions.	
If the ductwork system component is fixed against the face of the timber, has the thickness of its fixing bracket been taken into account when selecting fixings?	Adequate embedment depth is crucial for the effective functioning of a fixing. The thickness of the item being fixed against the face of the timber therefore needs to be taken into account when selecting fixings.	
Is the spacing distance between fixings in accordance with the fixing manufacturer's recommendations?	Fixing manufacturers provide detailed guidance about the spacing distances of fixings in different types of timber. Information can also be obtained from the Timber Research and Development Association (TRADA).	
Is the spacing distance between a fixing and the edge of the timber in accordance with the fixing manufacturer's recommendations?	Fixing manufacturers provide detailed guidance about the positioning of different types of timber. Information can also be obtained from TRADA.	
Does the fixing that has been chosen have a European Technical Approval (ETA) or other independent test certification that validates its performance?	It is recommended that the performance of a structural fixing is validated by an independent test body.	
What size washers does the fixing manufacturer recommend for this application?	Washers distribute the pressure of the screw or bolt head over an increased area.	
What drill setting is required for the timber into which the fixing is being made?	What drill speed and setting does the fixing manufacturer recommend?	
What diameter hole needs to be drilled for this fixing?	The manufacturer will provide guidance about the specific hole diameter that needs to be drilled for a particular fixing.	
What torque setting is required for this fitting?	The fixing manufacturer and TRADA may provide guidance about tightening torques for different types of timber.	

APPENDIX A: THE WEIGHT OF RECTANGULAR AND CIRCULAR DUCTWORK

Guidance about the weight of rectangular ductwork is given in the Hilti's Building Services Catalogue. This information is reproduced below. The weights shown are per metre length of galvanized, folded seam ductwork with 30 mm thick mineral wool insulation.

Sheet 0·75			Sheet 0·88						Sheet 1·0						Sheet 1·13						Sheet 1·25				
200	***224***	***250***	***280***	***315***	***355***	***400***	***450***	***500***	***560***	***630***	***710***	***800***	***900***	***1000***	***1120***	***1250***	***1400***	***1600***	***1800***	***2000***	***2240***	***2500***	***2800***	***3150***	***B/H***
7·6	8·0	8·4	10·0	10·7	11·6	12·5	13·6	14·6	17·7	19·3	21·1	23·2	25·5	27·9	34·0	37·4	41·2	46·4	51·6	56·7	78·2	86·6	96·2	107·4	***200***
	8·4	8·8	10·5	11·2	12·1	13·0	14·1	15·1	18·2	19·8	21·7	23·8	26·1	28·4	34·6	38·0	41·9	47·0	52·2	57·3	79·0	87·3	96·9	108·2	***224***
		9·2	11·1	11·8	12·6	13·6	14·6	15·7	18·8	20·4	22·3	24·4	26·7	29·0	35·3	38·7	42·5	47·7	52·8	58·0	79·8	88·2	97·8	109·0	***250***
			11·7	12·4	13·3	14·2	15·2	16·3	19·5	21·1	23·0	25·1	27·4	29·7	36·1	39·4	43·3	48·5	53·6	58·8	80·8	89·1	98·7	110·0	***280***
				13·1	14·0	14·9	16·0	17·0	20·3	21·9	23·8	25·9	28·2	30·5	37·0	40·3	44·2	49·4	54·5	59·7	81·9	90·2	99·9	111·1	***315***
					14·8	15·8	16·8	17·8	21·3	22·9	24·7	26·8	29·1	31·5	38·0	41·4	45·2	50·4	55·5	60·7	83·2	91·5	101·1	112·4	***355***
						16·7	17·7	18·8	22·3	23·9	25·8	27·9	30·2	32·5	39·2	42·5	46·4	51·6	56·7	61·9	84·6	93·0	102·6	113·8	***400***
							18·8	19·8	23·5	25·1	26·9	29·0	31·4	33·7	40·5	43·8	47·7	52·8	58·0	63·2	86·2	94·6	104·2	115·4	***450***
								20·9	24·6	26·2	28·1	30·2	32·5	34·8	41·8	45·1	49·0	54·1	59·3	64·4	87·8	96·2	105·8	117·0	***500***
									26·0	27·6	29·5	31·6	33·9	36·2	43·3	46·7	50·5	55·7	60·8	66·0	89·8	98·1	107·7	118·9	***560***
										29·3	31·1	33·2	35·5	37·9	45·1	48·5	52·3	57·5	62·6	67·8	92·0	100·3	110·0	121·2	***630***
											33·0	35·1	37·4	39·7	47·2	50·5	54·4	59·5	64·7	69·9	94·6	102·9	112·5	123·7	***710***
												37·2	39·5	41·8	49·5	52·8	56·7	61·9	67·0	72·2	97·5	105·8	115·4	126·6	***800***
													41·8	44·1	52·1	55·4	59·3	64·4	69·6	74·8	100·7	109·0	118·6	129·8	***900***
														46·5	54·6	58·0	61·9	67·0	72·2	77·3	103·9	112·2	121·8	133·0	***1000***
															57·7	61·1	65·0	70·1	75·3	80·4	107·7	116·0	125·7	136·9	***1120***
															61·1	64·4	68·3	73·5	78·6	83·8	111·9	120·2	129·8	141·0	***1250***
															65·0	68·3	72·2	77·3	82·5	87·6	116·7	125·0	134·6	145·9	***1400***
															70·1	73·5	77·3	82·5	87·6	92·8	123·1	131·4	141·0	152·3	***1600***
															75·3	78·6	82·5	87·6	92·8	97·9	129·5	137·8	147·5	158·7	***1800***
															80·4	83·8	87·6	92·8	97·9	103·1	135·9	144·3	153·9	165·1	***2000***
															86·6	90·0	93·8	99·0	104·1	109·3	143·6	151·9	161·6	172·8	***2240***
															93·3	96·7	100·5	105·7	110·8	116·0	151·9	160·3	169·9	181·1	***2500***
															101·0	104·4	108·3	113·4	118·6	123·7	161·6	169·9	179·5	190·7	***2800***
															110·1	113·4	117·3	122·4	127·6	132·7	172·8	181·1	190·7	202·0	***3150***

Source: Hilti, Building Services Catalogue

The following guidance about the weight of uninsulated, circular ductwork has been provided by Lindab.

Diameter mm	Area m²	Circumference m	Material thickness mm	Weight Kg/m	Weight Kg/3m
200	0·031	0·629	0·6	3·42	10·26
224	0·039	0·704	0·6	3·83	11·50
250	0·049	0·786	0·6	4·27	12·81
280	0·062	0·880	0·6	4·78	14·34
300	0·071	0·943	0·6	5·13	15·39
315	0·078	0·990	0·6	5·38	16·14
355	0·099	1·116	0·8	8·08	24·24
400	0·126	1·257	0·8	9·10	27·30
450	0·159	1·414	0·8	10·24	30·72
500	0·196	1·571	0·8	11·37	34·11
560	0·246	1·760	0·8	12·74	38·22
600	0·283	1·886	0·8	13·66	40·98
630	0·312	1·980	0·8	14·34	43·02
710	0·396	2·231	0·8	16·15	48·45
800	0·503	2·514	0·8	18·20	54·60
900	0·636	2·829	1·0	25·58	76·74
1000	0·786	3·143	1·0	28·43	85·29
1120	0·986	3·520	1·2	40·58	121·74
1250	1·228	3·929	1·2	45·28	135·84
1422	1·589	4·469	1·2	50·73	152·19
1500	1·768	4·714	1·2	54·35	163·05
1600	2·011	5·029	1·2	57·97	173·91
2000	3·143	6·286	1·2	72·45	217·35

Source: Lindab

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British Board of Agreement: www.bbacerts.co.uk

British Standards Institute: www.bsigroup.com

Construction Fixings Association: www.fixingscfa.co.uk

Eurocodes: www.eurocodes.co.uk

European Organisation for Technical Approvals (EOTA): www.eota.be

Steel Construction Institute: www.steel-sci.org

The Concrete Society: www.concrete.org.uk

Timber Research and Development Association (TRADA): www.trada.co.uk

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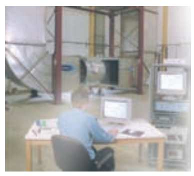

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